

THE ASSOCIATION OF CHROMOSPHERIC AND CORONAL
PHENOMENA WITH THE EVOLUTION OF THE QUIET SUN
MAGNETIC FIELDS

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INTRODUCTION

Using daily full-disk magnetograms and He I 10830 spectroheliograms to study the count and surface distribution of ephemeral regions over the solar cycle, Harvey (1985) concluded that the small dark structures seen in 10830, thought to correspond to X-Ray bright points (Harvey *et al.*, 1975), were more often associated with magnetic bipoles that appeared to result from an encounter of already existing opposite polarity magnetic flux than with emerging small magnetic bipoles (ephemeral regions). Such encounters would be more likely to occur in areas of mixed polarity. The fractional area of the Sun covered by mixed polarity fields varies anti-correlated with the solar cycle leading to a possible explanation for the 180° out of phase solar cycle variation of X-ray bright points. To establish the validity of this suggestion, a detailed study of time-sequence magnetic field, He I $\lambda 10830$, H α , C IV and Si II observations of selected areas of the quiet sun was initiated about 2 years ago. The preliminary results of this study are presented in this summary. A more detailed report will be published elsewhere at a later date.

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OBSERVATIONS

Eight observatories and instruments obtained a wide range of data during six observing efforts in 1983, 1984 and 1985, as follows: (1) National Solar Observatory: He I 10830 spectroheliograms (K. Harvey), (2) Big Bear Solar Observatory: longitudinal magnetograms and H α center-line filtergrams (F. Tang), (3) Ottawa River Solar Observatory: H α filtergrams through line (V. Gaizauskas), (4) Marshall Space Flight Center: longitudinal and transverse magnetograms (M. Hagyard), (5) Solar Maximum Mission, UVSP: C IV and Si II line profiles and He II spectroheliograms (A. Poland), (6) Solar Maximum Mission: FCS, O VIII spectroheliograms (J. Saba, K. Strong), (7) Very Large Array (VLA): 20 and 6 cm λ spectroheliograms (S. Habbal), (8) Swarthmore College: Ca II line profiles (R. Holt). Spatial resolution of these data was 1-3 arc-sec for the He I 10830, H α , and magnetic field data, and 10 arc-sec for the SMM UVSP and FCS data and the VLA observations. Temporal resolution was typically 3-5 minutes for the He I 10830, VLA cm λ and H α data and 5-7 minutes for the magnetograms and SMM data. Selected areas of the quiet sun and coronal holes were observed for periods of 4-10 hours each day during (1) 10-12 October 1983, (2) 28 November 1984, (3) 9 December 1984, (4) 25-28 May 1985, and (5) 25-27 June 1985, and (6) 8-9 September 1985.

RESULTS AND CONCLUSIONS

While the analysis and comparison of these data is still going on, there are several preliminary results and conclusions.

1. The network visible in He I 10830 displays a low level intensity variation over a spatial scale of the order of arc-seconds and a time scale of minutes. These intensity variations are somewhat oscillatory in appearance and decrease toward the limb, almost completely disappearing at longitudes $>45-50^\circ$. This suggests that the observed variations may be due in part to motions of network spicules and fibrils.
2. He I 'dark points' have a characteristic size of 10-30 arc sec and intensity variations that show a variety of time scales from minutes to several hours. Their observed behavior and size are similar to that seen in EUV (Habbal and Withbroe, 1981) and X-ray bright points (Nolte *et al.*, 1979; Sheeley and Golub, 1979). Two types of localized

darkening in He I 10830 are defined as dark points: (1) a rapid, almost flare-like, darkening. These events have a duration of about 10-30 minutes and often appear to be associated with ejecta, and (2) a longer lived darkening lasting hours, but which can show large amplitude intensity variations (50-120%) on a time scale of minutes.

Approximately 32% of the 10830 enhancements are associated with ejecta, a macrospicule, small-scale filament eruption, or a propagating disturbance of some type. The propagating disturbances are sometimes seen as a dark, front-like arch-shaped cloud in 10830 moving with horizontal velocities ranging from 16-140 kms^{-1} over distances from 20,000-70,000 km. (In a few cases, possible effects of these disturbances are detected out to distances of 200,000 km.) Also seen in the 10830 spectroheliograms are small (3-6 arc sec) bright structures that persist for one or two frames (~ 3 min). These are interpreted as a predominately vertical velocity structure. They occur at a rate of 2.6-3.9/hr/ 10^{10} km^2 . Comparisons with filtergrams taken at several positions through the $\text{H}\alpha$ line indicate no corresponding velocity structure associated for two such 10830 "velocity" points. Complex dynamics, however, are seen in an $\text{H}\alpha$ structure corresponding to a He I dark point overlying the site of disappearing magnetic flux.

3. Almost all of the 10830 dark points are spatially associated with magnetic bipoles. For 8 days of the 11 day data sample, a comparison has been made between the occurrence of He I dark points with the observed evolution of the underlying photospheric magnetic field. During the 8 days of observation, 477 He I dark points (both rapid and long-lived) occurred. 15% of these were co-spatial with ephemeral regions that have emerged during the observing period; 39% occurred at sites of disappearing flux that resulted from the encounter of existing, unrelated opposite polarity flux. The onset of the darkening seen in He I began when the approaching opposite polarity network elements are within 3-5 arc-sec or adjacent. In $\text{H}\alpha$, connecting fibrils or a small filament are seen to form between the approaching opposite polarity features. For 46% of the dark points no change was seen in the associated magnetic fields. Only 10% of the ejecta events occurred with ephemeral regions; 35% with encounters of opposite polarity magnetic flux.

In the reverse correlation considering magnetic field changes with He I dark points, about one-third of 307 identified ephemeral regions (31%)

were associated with a dark point; two-thirds (69%) were not. 57% of the 363 disappearing magnetic flux sites were associated with He I dark points, and 43% had no dark structure. 21% of the ephemeral regions were associated with ejecta events; 36% opposite polarity magnetic flux encounters were associated with ejecta.

We conclude that He I dark points and ejecta events are more likely (by a factor of 2-4) to be associated with encounters of existing opposite polarity flux than with the emergence of magnetic bipoles. Conversely, encounters of magnetic flux of opposite polarity are almost two times more like to result in an associated dark point in He I than ephemeral regions. Not all ephemeral regions and occurrences of encounters of unrelated opposite polarity magnetic network are correlated with He I dark points.

4. There is a good, though non one-to-one, correspondence between the locations of He I $\lambda 10830$ dark points and the bright structures observed in C IV. Most of the He I dark points have a bright C IV counterpart at some time during their lifetime. Though not all C IV bright points correspond to dark He I dark structures. A comparison of the intensity variations and velocity field between C IV and He I in the 10830 dark points is now being conducted and will be discussed in more detail in a later paper.

5. A good association has also been found between the positions of He I dark points and the bright points observed in 20 cm λ images with the VLA. For many of the He I and 20 cm structures, similar intensity variations are seen, both in the long and short time scales. Seven (7) of the 11 bright 20 cm points studied so far are located at sites of disappearing magnetic flux resulting from the encounters of existing opposite polarity magnetic flux; in two (2) 20 cm bright points, magnetic flux is both emerging and disappearing, and in the remaining two (2), there is no obvious change seen in the magnetic field. The results of this comparison are being presented separately in this workshop proceedings by S. Habbal and K. Harvey.

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